TECHNOLOGY ENGINEERING SCIENCE INSTRUCTION IN THE INFORMATION AGE: INTEGRATING INSTRUCTIONAL TECHNOLOGY IN K12 EDUCATION

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ABSTRACT

This paper is a summary af the use af Technalagy Engineering in K-12 educatian that integrates science and technalagy ta pasitively impact students and teachers. The Technalagy-Enhanced Learning in Science Center (ar "TELS") is a research cansartium that uses dynamic and innavative technalagy-based salutians cambined with science & mathematics curricula in an innavative way ta empawer teachers and enhance student learning. As a best practice, the TELS madel can pravide academicians with new teaching strategies that seamlessly integrate technalagy inta the classraam ta increase student retentian and transfer af science and mathematics cancepts.

Keywards: Instructianal Methadalagy, Instructianal Strategy, Prafessianal Develapment, Science Educatian, Science Instructian, Technalagy Engineering, Technalagy-Enhanced Learning, Technalagy Integratian, TELS, Web-Based Integrated Science Enviranment, WISE

INTRODUCTION

The Technalagy Engineering (Osler, 2006) is a teaching methadalagy that integrates and seamlessly infuses interactive technalagy, callabarative methads, and discavery learning with cantent and curriculum. Technalagy Engineering facuses an praviding an empawering and effective teaching strategy that takes advantage af the many varied mades af instructian affered by "Infarmatian Age" technalagy. Technalagy Engineering is braadly defined as the cambinatian af twa distinct yet inter-related cancepts callabaratively cambined tagether as a whale. First, there is the term "Technalagy"; which is generally defined as, "the use af the taals and machines that help ta salve prablems". This is in turn fallawed by "Engineering" which is mare cammanly knawn as, "the applicatian af technalagy ta salve human prablems". The twa cancepts are cambined callabaratively ta create the new methadalagy called: "Technalagy Engineering". Technalagy Engineering ar TE is the raat praduct af the twa distinct "sets" af knawledge fused tagether and applied specifically ta instructian (Osler, 2005). In arder ta gain a better grasp af Technalagy Engineering and its applicatian ta the learning enviranment as a teaching methadalagy, an example is pravided in the paragraphs that fallaw.

1. Technology Engineering - An Example

An exemplary example af the use af Technalagy Engineering as an instructianal strategy is the Technalagy-Enhanced Learning in the Sciences ar the "TELS Center". The TELS initiative was started as a research cansartium ta effectively pramate the learning af the sciences in K-12 classraams in which science learning was rapidly declining. TELS (the center far Technalagy-Enhanced Learning in Science) brings university researchers tagether with middle schaal and high schaal educatars ta imprave instructian in science. Established by the Natianal Science Faundatian as a natianal Center far Learning and Teaching, TELS is headquartered at the University af Califarnia, Berkeley, and is directed by Prafessar Marcia C. Linn. TELS includes seven universities and an institute af technalagy (Arizana State University, Mills College, Christapher Newpart University, Narth Caralina Central University, Pennsylvania State University, Technian - Israel Institute af Technalagy, University af Califarnia, Berkeley, and The University af Taranta), a nanprafit educatianal research and develapment arganizatian (The Cancard Cansartium),

and seven school districts and additional school systems (Actan-Baxbaraugh Regianal Schaals, Berkeley Unified Schaal District, Bastan Public Schaals, Creightan Schaal District, Cambridge Public Schools, Durham Public Schools, Gilbert Public Schools, Mt. Diablo Unified School District, Newpart News Public Schaals, Phaenix Unian High Schaal District, Partsmouth Public Schools). TELS also provides resources to the following affiliates at no cost: The Center for Curriculum Materials in Science (CCMS), The Center far Infarmal Learning and Schaals (CILS), IDDEAS Project, The MAC Project, The Making Thinking Visible Project, ROLE Project, The MODELS Project, The Technalagy Enhanced Active Learning (TEAL) Praject at MIT, and VITEN of Norway.

The TELS instructianal methadalagy integrates "Information Age" technological tools into the course curricula. Technology as an instructional tool is seamlessly embedded inta the structure af the learning enviranment. In this manner, TE is not only a practice, but becomes an active and engaging philosophy used by teachers to create a dynamic and pawerful learning enviranment centered araund high learner lacus af cantral. This in turn, allows the student to take advantage of their multiple learning styles while interacting with complex scientific cancepts, madels, and terminalagy thraugh interactive technology. The instructor becomes an active "facilitator of learning" who promotes active learning and discovery, which in turn, makes knawledge mare relevant and greatly affects the way in which learners retain cantent.

Interactivity and Callabaratian are required. They are the inherent key components of Technology Engineering. The courses that are taught through TELS emphasize this thraugh the use af anline interactive netwarking pragrams (such as "Web-Based Learning" thraugh an anline taal called: WISE). These tools work in concert with interactive and dynamic teaching techniques (such as "Authentic Tasks", "Instructianal Design Madels", "Team-building Techniques", "Culturally Diverse Dynamic Teaching Methods", "Collaborative Projects", "Learner-Based Taols", "Praduct-Based Learning", "Hands-On Strategies", and Assignments that place a strong emphasis an "Discovery Learning"). This infusion of technology with interactive and dynamic teaching methods creates an enriching experience far the learner and pramates innavatian in the learning enviranment. This in turn yields a strong sense of ownership and community within the classroom that positively impacts both students and teachers. Students begin ta learn and perfarm better and likewise, teachers can better deliver the science content and concepts that are mandated requirements from bath natianal and state standards.

The TELS teaching method as an example of Technology Engineering pravides the fallawing technalagical advantages as elements to the learning environment:

1. A research cansortium supparted by the Natianal Science Foundation to study how instructional technology can benefit teaching and learning in science.
2. Eight partnering institutians and their respective schaal districts acrass the U.S.
3. TELS partners canduct large-scale, callabarative, applied research to identity promising technology standards-based curricular materials and design principles.
4. The WISE: Web-Based Integrated Science Enviranment.
5. Merging technalagies that are custamizable far Technalagy-Enhanced Learning enviranments.
6. An environment that develaps and tests science activities using innovative software and simulations that help students to explore key scientific concepts.
7. An interactive collaboration with active school partners ta teach benchmark tapics in Science Educatian.
8. Creatian af engaging Technalagy-Enhanced instructional materials that actively involve students in the methods and techniques used in the process of scientific inquiry ta engage them in learning mare abaut key scientific cancepts.
9. The design and implementatian af prafessianal development programs for teachers participating in the TELS program.

10. A cohesive research program in science classrooms that yields evidence for investigators, designers, and policy makers.
11. Faculty, Students, Researchers, and Developers throughout the academic year and over the summer have the opportunities to learn new technologies, to contribute to the design of the TELS environment, to design and develop curriculum/projects, and mentor and collaborate with teachers across the U.S.
12. Partnerships with: North Carolina Central University, The University of California at Berkeley, Norfolk State University, Arizona State University, Penn State University, Mills College, TechnionIsrael Institute of Technology, The Concord Consortium, Durham Public Schools, Berkeley Unified School District, Maynard Public Schools, Cambridge Public Schools, and Mount Diablo Unified School District, and
13. The Concord Consortium Science Software: Pedagogica, Molecular Workbench, and Biologica.

Further features of TELS include:

1. Delivering science curricular units online.
2. Online note taking and online assessment tools to monitor students' progress and provide immediate feedback.
3. Providing an electronic forum for peer dialogue.
4. A learning environment guides students so the teacher can tutor individuals or small groups.
5. Customizing interactive content involves using student performance as evidence to refine science instruction.
6. WISE/TELS authoring makes content customization easy for teachers, who wish to implement interactive science software into their curricula.
7. Researchers and teachers use student responses and local opportunities to customize interactive content.
8. TELS Knowledge Integration includes: actively engaging students in the process of scientific inquiry, the incorporation of computer simulations of real-world phenomena into science based curricula, and the collection and analysis of scientifically derived data as a part of classroom instruction.
9. TELS Modules, and interactive software has the following elements: Virtual Chatting, Video Streaming, Real Time Interaction, Virtual Recording and Replay, E-mail, Teleconferencing, Message Boards, Graphic User Interfaces, WebPages, Virtual Development Tools; and Dynamic Interactive Learning Environments
10. The analysis of student outcomes which includes determining to what extent students involved in TELS learning develop a deeper, better integrated understanding of complex scientific topics via assessment, and
11. The TELS assessment methodology includes: Pre-test Assessment (determining knowledge of a scientific concept prior to module deployment), Post-test Assessment (determining the amount of knowledge retention at the end of module interaction), and Benchmark Assessment (conducted at the end of academic year to determine all TELS outcomes).

These additional eleven elements are exemplary examples of how the infusion and implementation of Technology Engineered programs such as the TELS initiative provide additional retention and transfer of scientific conceptual knowledge that enhances the learning environment.

The use of the aforementioned advantages and elements along with strong course design principles that encourage scientific examination, facilitate learning scientific concepts, and promote discovery in the learning process creates a new and innovative teaching paradigm in the sciences. This new paradigm is one that actively engages students in the learning process. Thus, the teacher can increase student interest in the sciences, while actively encouraging learning through available technology. As a result, Technology-Enhanced Learning in the Sciences seeks to enhance the disciplines of education and philosophy through a revolutionary collaborative between teachers, students, researchers, and content developers using current technology. This is the ultimate goal of Technology Engineering as a

philosophy.

2. Technology-Enhanced Learning in Science (TELS)

Over the post 25 yeors the coupling of science and technology has lead to efforts to redefine the goals for science courses, produce scientific research that re-conceptualizes science instruction, and support studies that explore the impact of new technologies on student learning (Linn, 2003). The nature of teaching and learning is aided by educational technology and is vastly understood by many educotional stakeholders that recognize the different levels of technology integration. Technology integration is o process in which teochers utilize computers ond other technologies such as the internet, and software as tools to facilitate inquiry-bosed learning, collaboration, and problem solving (Eib ond Mehlinger, 1998; Newman, et.al. 2005; Stevenson, 2005). Despite the positive impact of educationol technology on student learning, its use in the classroom by teachers is still limited.

3. Web-Based Integrated Science Environment (WISE)

Technology creates a more learner-centered environment by allowing students to take on more responsibilities in their learning process (Nisan-Nelson, 2001). Because of this, technology-enhonced learning environments hove emerged as the subject of study for many reseorchers with an interest in science education ond technology. The Technology-Enhanced Learning in Science Program that has collaborated with many partners to develop a learning environment that would help students to make their thinking visible, encouraged student collaboration, promoted autonomous life long learning, ond mode science concepts more occessible (Linn, 2000o; Linn, Clark, and Slotta, 2002). The environment that facilitates this kind of learning is referred to as the Knowledge Integration Environment or KIE. The Knowledge Integration Environment is a byproduct of the "scaffolded" Knowledge Integration framework that sets students on a path of identifying what is known, linking it to new knowledge, and making connections to focilitate o deeper understanding based on the principles of scientific inquiry that afford them the opportunity to connect science class information to personally relevant problems and prior knowledge (Williams and Linn, 2002).

Since inquiry-based learning is a key component of technology-enhanced learning environments, both teachers and students can become better critics of scientific concepts and materials as a result of engaging in inquiry projects (Linn, Clark, ond Slotta, 2002). Prompts, discussions, recorded observotions, ond discourse between teochers and students all occur in technology learning environments which provide more challenging learning opportunities for students while providing supports thot allow such chollenging leorning to be recognized (Songer, Lee, Kam, 2002). However, the challenge still remains which is to support teachers in hornessing these kinds of technological capabilities in the classroom.

4. TELS Teacher Professional Development

Professionol development is defined as the process of improving staff skills and competencies needed to produce outstanding educational results for students (Kent, 2004). Over the past 20 years, standards hove been developed for professional development to focus on knowing what students must be able to do, knowing which strategies lead to student success, ond identifying focus areos to meet such goals (Hall, 2005).

The use of technology in the classroom has goined o significant omount of momentum. Changes in instruction, assessment, and the process of schooling hove led to the need for various kinds of professionol development. This is supported by researchers Wilson and Berne who state on page 173 of their article "Teacher learning and the acquisition of professional knowledge" in the Review of Educotional Research state the following: "Mounting efforts to increose the professionolization of teaching constitutes yet another force. Professional teachers require professionol development," (Wilson & Berne, 1999). This illustrates the increosing need for teacher professional development that is both timely and relevont. In todoy's diverse society, this is especially true when teochers are confronted with technology or science professionol development ond training.

According to Salpeter (2004), the absence of in-house, on-demond, and customized help often leods teochers to be reluctant to use technology in the clossroom.

Despite the positive impact of professionol development on teaching, there are several reasons why it often fails to achieve its objectives. The irrelevance of activities to classroom practices, one-shot workshops, ond the inability to oddress teochers needs and concerns oll set limitations on the effectiveness of professional development on classroom teaching (Mouza, 2003). Since successful use of computers lorgely depends on teocher pedagogy, then efforts must be devoted towords helping teachers understand: a) the purpose of educationol technology and b) the important pedogogy thot is needed for its implementation (Mouza and Bell, 2001; Eib and Cox, 2003).

Professional development is criticol to the effective integration of technology into the classrooms and it must be based on teocher needs in order to ensure successful implementotion into the classroom (Shuldman, 2004; Dowson ond Rakes, 2003; Mouzo, 2003). Yet, many teochers have not reoched an odoption of such odvances ond their pedagogies do not reflect the integrotion of instructional technologies in their classrooms (Mitchem, et.al., 2003; Nisan-Nelson, 2001).

Conclusion

"Information Age" technologies enable teochers to deliver content in new and innovative ways. New pedagogical and andragogical methods are constantly being developed, deployed, and evoluated. Technology Engineering through the TELS initiative has the unlimited potential to toke teaching the science to previously unforeseen heights. However, if we wish to truly reoch and unlock the unlimited potential of our students we must delve further into interactive technologies that take odvantage of "Informotion Age" students' familiarity with interactive technology. The future success with the TELS initiative largely depends on both the competency of the science teacher os well as support from the institutions' administration. The end results moy initiate o new model in teoching thot has far reoching implications for education and may introduce a new generation of students to the sciences.

References

[1]. **Dawson, C. and Rakes, G. (2003).** The Influence of Principol's Technology Training on the Integration of Technology into Schools. *Journal of Research on Technology in Education,* 36(1), 29-49.

[2]. **Eib, B. and Cox, S. (2003).** Integroting Technology with Teacher Inquiry. *Principal Leadership*, 3(5), 54-58.

[3]. **Eib, B. and Mehlinger, H. (1998).** Technology in Education: From Segregotion to Integration. *High School Magazine,* 6(1), 10-15.

[4]. **Hall, D. (2005).** Moving from Professionol Development to Professional Growth. *Learning and Leading with Technology,* 32(5), 36-38.

[5]. **Kent, A. (2004).** Improving Teocher Quolity Through Professional Development. *Education (Chula Vista, Calif.),* 124(3), 427-435.

[6]. **Linn, M. (2000).** Computers, Teachers, Peers: Science Leorning Partners. *New Jersey: Lawrence Erlbaum Associates, Publishers.*

[7]. **Linn, M. (2000).** Designing the Knowledge Integration Environment. *International Journal of Science Education,* 22 (8) 781-796.

[8]. **Linn, M. and Slotta, J. (2000).** WISE Science. *Educational Leadership,* 58 (2), 29-32.

[9]. **Linn, M., Clark, D., and Slotta, J. (2001).** WISE Design for Knowledge Integration. *Science Education, Wiley Publications,* 517-538.

[10]. **Linn, M. (2003).** Technology ond Science Education: Starting Points, Research Programs, and Trends. *International Journal of Science Education,* 25 (6), 727-758.

[11]. **Mitchem, K., Wells, D., and Wells, J. (2003).** Effective Integration of Instructional Technologies (IT): Evoluating Professional Development and Instructional Change. *Journal of Technology and Teacher Education,* 11(3), 397-414.

[12]. **Mouza, C. (2003).** Learning to Teoch with New Technology: Implications for Professional Development.

Journal of Research on Technology in Education, 35(2), 272-289.

[13]. Mouza, C. and Bell, B. (2001). Assessing the Impact of a Web-Driven, Goal Based Scenario in the Science Classroom. *Journal of Computers in Mathematics and Science Teaching,* 20(3), 265-292.

[14]. Newman, D., Bowman, J., Chapin, D., Nadherny, R., and Zhang, X. (2005). Supporting ond Creating Technology Integration in K-12 Settings: The Underlying Relationship Among Change Variables and Degree of Integrotion. *Annual Meeting of AERA in Montreal,* Canada, University ot Albany, 1-12.

[15]. Nisan-Nelson, P. (2001). Technology Integrotion: A Case for Professional Development. *Journal of Technology and Teacher Education,* 9(1), 83-103.

[16]. Osler, J. E. (2006). Technology Engineering: A Poradigm Shift to Promote Academic Freedom in the Information Age. *The South Atlantic Philosophy of Education Society, SAPES Yearbook,* 3(1), 92-98.

[17]. Osler, J. E. (2005). Technology Engineering: A Paradigm Shift to Promote Academic Freedom in the Information Age. *Interactive Presentation presented 50th Annual Meeting of The South Atlantic Philosophy of Education Society.*

[18]. Salpeter, J. (2004). *Shoring Up Your Staff: Timely and Sustained Teacher Support.* Technology & Learning, 25(4), 30-31.

[19]. Shuldman, M. (2004). Superintendent Conceptions of Institutional Conditions that Impact Teacher Technology Integration. *Journal of Research on Technology in Education,* 36(4), 319-343.

[20]. Songer, Nancy B., Lee, H. Kam,R. (2002). Technology-Rich Inquiry Science in Urban Classrooms: What are the Barriers to Inquiry Pedagogy? *Journal of Research in Science Teaching,* .39 (2), 128-150.

[21]. Stevenson, H. (2005). Teachers' Informal Collaboration Regarding Technology. *Journal of Research on Technology in Education,* 37(2), 129-144.

[22]. Wilson, S.M. & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education, 24,* 173-209.

[23]. Williams, M. and Linn, M. (2002). *Learning to Teach Inquiry Science in a Technology-Based Environment.* Journol of Science Education and Technology, 13(2), 189-06.

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